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SKIASCOPY;

OR, THE

"SHADOW" TEST FOR THE DETERMINATION OF THE REFRACTION OF THE EYE.

A Lecture delivered before the School of Ophthalmology.

BY

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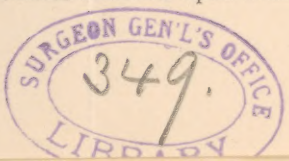
GENTLEMEN: In our studies of the methods of determining the refraction of the eye by means of the ophthalmoscope up to this time, we have dealt with those ordinarily employed, which gave an image, real or virtual, of the details of the fundus oculi—optic nerve entrance, retinal vessels, etc. These are the classical methods and will always remain in vogue, because of their indispensable value in general diagnosis; and for this reason they should be cultivated assiduously by all those who wish to make themselves proficient ophthalmoscopists.

There is, however, another method of ophthalmoscopic optometry, recently brought into practice, which, though based upon the same optical principles as these, differs from them in some points of practical detail. It is a method which has been enthusiastically recommended and endorsed by some, while by others, of equally good authority, it is regarded with indifference or distrust. There are those who look upon it as most



inaccurate or unsatisfactory, but many regard it as probably the simplest and most trustworthy and valuable plan of objectively determining the refraction which we have at our command. The Germans use it scarcely at all; the French, among whom it originated, are divided in opinion as to its usefulness, while in England it is to-day the most generally adopted method for the ophthalmoscopic diagnosis for refraction. The eclectic character of the American is shown in this as in all other questions, and the "shadow-test" finds adherents and detractors in almost every town and city where scientific ophthalmology is practised. Its very simplicity of execution is brought forward as an argument against it, because, it is averred, if it should come into general use the other methods of ophthalmoscopic examination, particularly that by the direct method, which are so important on other accounts, would be neglected. I have yet, however, to learn, gentlemen, that simplicity is an objectionable quality in any procedure which is as accurate and reliable as others more complicated, and we have no need to fear that the determination of refraction by the ordinary methods of ophthalmoscopic examination are likely to fall into desuetude, "innocuous" or otherwise. No one method so completely occupies the field as not to allow room for one more; and even though you may adopt the shadow-test as a routine method of determining refraction, you will still find use for your refraction-ophthalmoscopes.

The method under consideration is known by a large number of names, no one of which is accurately descriptive of its underlying principles.[1]

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[1] It was called *keratoscopie* by its discoverer (Cuignet) and is still so-called by a number of French writers. This is a misnomer, for we do not inspect the cornea at all, and it plays only a part in the production of the phenomena. *Retinoscopy*, used almost alto-

Out of the multitude, I have selected one which seems to me, on the whole, the least objectionable and which is not likely to be confounded with anything else of a similar character.

The most prominent—in fact, the guiding—feature of the method, is the shadowy edge of an illuminated area which apparently passes across the pupillary space. In all descriptions of the method you will find that it is to this shadow bordering the bright area that attention is directed, and this being so and there being no other method of examination to which the term can be applied, the "shadow-test" seems, all things considered, about as appropriate as any that has as yet been suggested. It does not commit us to any special theory and there is no liability to confusion—two very strong points in nomenclature. If we want to be scientific and classical we may say "skiascopy" (*σκιά*, a shadow; *σκοπέω*, I look at).

The manner of performing skiascopy is very simple: Take an ophthalmoscopic mirror—plane or concave—and, holding it at a distance of forty or sixty inches (1 m. or 1.33 m.) from the eye to be examined, throw the light coming from a flame behind and above the head of the patient into the pupil. The pupillary space will, of course, appear brightly illuminated. Then rotate the mirror

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gether by the English, is equally incorrect, for we do not inspect the retina, but only the image of the bright image formed on the fundus, and which may not be on the retina at all, but on the optic disk. *Pupilloscopy* (*koroscopy*) is somewhat better chosen, since without a pupil to admit the light, we could have no phenomena; but it is evident that it is not the pupil we inspect or which gives us the information we seek. *Fantoscopie retinienne* is merely an approximation to the true explanation. *Retinoskiascopie* is somewhat better, while *dioptroscopie* can mean nothing, since we do not inspect, but measure, the refracting power of an optical apparatus.

slightly on its vertical axis, and a brightly illuminated area, bounded by a dark shadowy edge, will appear to pass horizontally across the pupillary space. The intensity of the illumination and the direction and rate of its movement—or rather that of its shadowy edge—form the basis of the diagnosis of the refractive condition of the eye under examination.

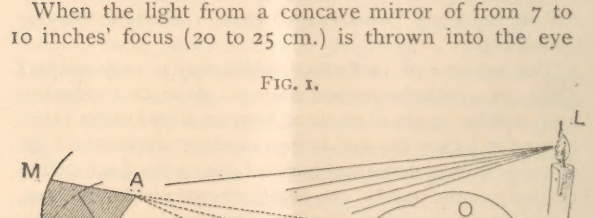
How this is made possible it is our present purpose to inquire.

The phenomena of the shadow differ, accordingly as the experiment is made with a plane or a concave mirror, the reason whereof will be very apparent when we have examined the matter a little further. We shall first study

SKIASCOPY WITH THE CONCAVE MIRROR.

When the light from a concave mirror of from 7 to 10 inches' focus (20 to 25 cm.) is thrown into the eye

FIG. 1.



from a distance of sixty inches, the source of illumination is not the flame behind the head of the patient, nor the mirror itself, but the inverted image of the flame, L (Fig. 1), formed by the mirror, M, at its focus, A, which is, in this case, about forty or fifty inches in front of the observed

eye, O. From this focus of illumination a cone of divergent rays proceeds, which forms a large circle of illumination on the face, a part only of the rays passing into the pupil. The light, however, that does pass in at the pupil is refracted by the optical media of the eye and finally strikes the retina.

Now, the manner in which these rays shall strike the retina depends upon the refractive condition of the eye. Let us suppose, in this instance, that the eye is myopic. In that case the rays proceeding from A will, after entering the eye, cross at e' and, passing on, form on the retina a diffusion image, $f\,d$ of A, with its centre at a. This image, or bright spot, now becomes in its turn an illuminated object, sending out rays of light, just the same as if it were an originally luminous body. And just here is where I think many students of ophthalmoscopy find a hitch in their clear comprehension of the optical phenomena involved.

In the first place, you must remember that after the light gets into the eye and falls on the retina, the source of illumination is to be disregarded and we have only to do with the illuminated retinal surface, which might just as well have been illuminated from behind as through the pupil, as, indeed, we have already many times demonstrated to you on the artificial eye. We throw light into the eye not to get a reflection from the retina as from a plane bright surface like a mirror, but for the same reason that we open a window of a dark room, namely, to illuminate the objects we wish to see, and not to get a reflection of the sun and sky from these objects.

Another possible source of confusion, as I have found, is in the mistaken application of the law of conjugate foci. We have taught and demonstrated to you that in conjugate foci the image can replace the object, and the object the image, showing that the rays of light follow the same path going and coming. Its application in

this instance, however, is not, as I have found many students to suppose, to the flame image A, and the illuminated area *d f*, but to the area *d f*, and its image at *a'*. The rays from the area *d f* do not cross at *e'* and go back to A, but diverge like the rays from any other illuminated object and, striking the refracting media in the front of the eye, are brought to a focus and form an image of it at the far point of the eye (*a'*), where an object must be, in order to have its image formed clearly and distinctly on the retina. In other words, *the retina and the far-point of the eye are conjugate foci.* We shall find this fact to lie at the basis of this method of examination and you should get it clearly fixed in your mind, otherwise there will come a point in your studies of it when you will find yourself in inextricable confusion.

Taking, then, *d f* as the illuminated object and assuming, as we have done, that the eye is myopic, an image of the area *d f* will be formed by the refracting media *in front* of the eye and at the conjugate focus of *d f*, that is, at the far point of the eye *a'*. Now the distance of the far-point *a'*, as we have learned, depends upon the degree of the myopia (that is, upon the amount of the increase in the length of the eyeball), being closer to the eye in the high degrees and getting farther and farther away as the degree decreases, until it reaches infinity, when myopia ceases and emmetropia sets in.

Suppose, now, we rotate the mirror on its axis from *M* to *M'*. The image of *L* will then move from *A* to *B*, and remaining, as before, the source of illumination, form on the retina the blurred image *g h*, the rays having crossed at *e*. The rays coming from this illuminated area *g h*, like those coming from *d f*, must come to a focus in front of the eye and form an image at the far point *b'*. In making this rotary movement of the mirror the following important changes will have been noted, viz.,

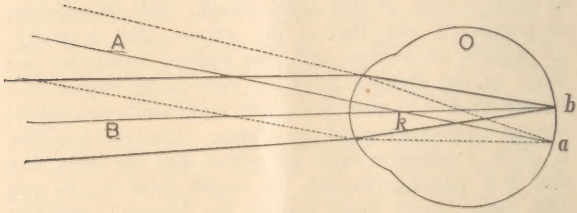
that while the movement of the illuminated area on the retina has been the opposite of that of the mirror, the movement of the aërial image of this area, at the far point of the eye, has been in the same direction as that of the mirror. If, therefore, on rotating the mirror before the eye, at a distance of sixty inches, we find the shadowy edge of the bright image to pass across the pupillary space in the same direction as the mirror, it shows that the image is formed between the mirror and the eye (at its far point), and consequently there must be M greater than 1 D. And not only that, but the amount of displacement of this aërial image, with its shadow, as compared with that of the mirror—that is to say, its rapidity of motion, will also depend upon the distance of the shadow from the eye; being slower and shorter when it is near and more rapid and more extensive as it recedes toward the mirror. The reason of this is at once apparent when we notice that the lines A *k* and B *k*, passing through the nodal point of the eye and upon which these images are formed, gradually approach as they go toward the eye and finally come together at the nodal point *k*. While, therefore, the *direction* of the shadow movement, *with the mirror*, gives us knowledge of the existence of the myopia, the relative *rapidity* of its movement gives us some knowledge of its degree, though only vaguely.

These phenomena are, of course, only possible when there is an actual aërial image of the illuminated retinal area formed between the observer and the eye under observation—that is, when, as in the case under consideration, the myopia is greater than 1.25 or 1.5 D., because when the myopia is lower than 1.25 D., the image is no longer formed in front of the observing eye, but the rays going to form it behind the mirror strike the eye of the observer as they come immediately from the object —that is to say, the object and not its image, real or

virtual, is seen; and, of course, any change in its position on the retina is observed in a direct manner; and as the movements of the bright area on the retina are the opposite of those of the image A and of the mirror, the shadow movement, in this case, will be the opposite, or *against* the mirror movement.

The same conditions are present, too, when the rays emerge parallel, as they do when the eye is emmetropic. In Fig. 2, the rays from the area at *a* emerge parallel in

FIG. 2.



the direction A, and when it moves to *b* in the direction B, and the image is at infinity, and is infinitely large. The eye of the observer, however, intercepting the rays in their course, forms the image on its own retina and sees it and its movements directly and as they are—that is, when *a* moves to *b*, from right to left, the movement appears, to the observing eye, to be from right to left.

In *emmetropia*, therefore, and in *low degrees of myopia* in which the far point is behind the mirror, the *movement of the shadow is against* that of the mirror.

We must have, necessarily, a very different set of phenomena when the eye is *hypermetropic* and the rays from the illuminated retinal area emerge divergently. (Fig. 3.) Here the bright area cannot be seen directly, as in emme-

tropia, or in the lower forms of myopia, nor is there a real image of it formed anywhere, as in myopia of the higher degrees.

The eye of the observer, however, placed in the path of the diverging rays, refers their origin to a virtual image, *e*, behind the eye (at its far-point, which, as you know, is negative in the hypermetropic eye), where they would all meet if prolonged backward. When the bright area is moved by the rotation of the mirror from *a* to *b*, the virtual image moves in the same direction from *c* to *f* —that is, *against* the movement of the mirror.

It will be noticed, too, that the more divergently the rays emerge from the eye—that is, the higher the degree of hypermetropia, the closer behind the eye will be the virtual image. As a result of this, the extent of movement of the shadow will be less the higher the degree of hypermetropia, gradually becoming greater as the degree increases, until it reaches infinity and the rays emerge parallel and the hypermetropia merges into emmetropia. It is easy to see that when the virtual image is at *e* and is displaced on rotation of the mirror to *f*, the extent of movement is less than when it is at *c* and displaced to *d*.

We thus see that the direction of the shadow movements, when the source of illumination is the image of a flame produced by a concave mirror held about forty inches in front of the observed eye, gives us positive and definite information as to the refractive condition of the eye, and we recapitulate it as follows:

1. Movement of shadow *with* the mirror: myopia greater than 1 D.

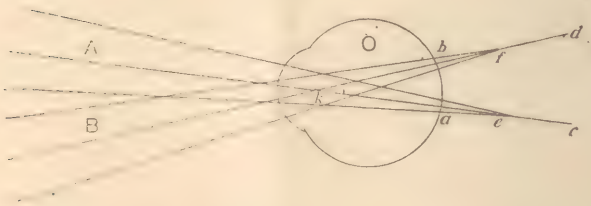
2. Movement of shadow *against* the mirror movement: hypermetropia, emmetropia or myopia less than 1 D.

We know also, further, that the *movement is less the greater the amount of ametropia* (M. or H.).

As regards the *distinctness of the shadowy edge* and

the intensity of the contained bright area, it is curious to note that diametrically opposite opinions are held.

FIG. 3.



Thus, Hartridge,[1] who is the latest English authority on the subject, says:

"It is in the lower degrees of ametropia that we get the brightest and best defined shadows. The clearness of the image and the brightness of its edge decrease as ametropia increases." (P. 87.)

On the other hand, Galezowski, in the last edition of his treatise on the eye, states:

"The shadow is darker and its movement slower in proportion as the ametropia is greater. Of these two peculiarities the first is due to the fact that the enlargement of the virtual image in H. and of the real image in M. is much less as the M. or H. attains a higher degree. The same quantity of light and shadow being distributed over less surface, the illuminated area is necessarily brighter and the shadow denser."[2] (P. 824.)

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[1] The Refraction of the Eye. By Gustavus Hartridge. Third edition. Philadelphia: P. Blakiston Son & Co., 1888.

[2] Traité des Maladies des Yeux. Par Dr. X. Galezowski. Third edition. Paris: J. B. Ballière, 1888.

Both, it is very evident, cannot be right, and Mr. Hartridge is the more nearly correct. He neglected, however, to state that the brightest area with the best defined shadow in this method of examination is in that degree of myopia in which the image of the flame formed by the mirror lies at the far-point of the eye[1]—that is, when A and *a'* fall together (Fig. 1). This image is then at conjugate focus with the retina, on which a clear and sharply defined image is formed, and the image of this image, formed by the dioptric apparatus of the eye, which is the one we see, is also bright, with sharp edges. Now as the retina moves backward or forward from this position of conjugate focus (the mirror remaining in the same position)—that is to say, as the eye becomes hyperopic or myopic, the retinal image becomes larger in extent, but less bright and with more blurred outline, the same amount of light covering a larger area.

It should also be remembered, in this connection, that the size of the pupil controlling, as it does, the amount of light entering the eye (in fact, the retinal bright area is, to a degree, an image of the pupil) has much to do with the brightness of the image, as does also the amount of pigment at the part of the fundus on which the illuminated area is formed. There are so many factors entering into the production of the brightness of the image, which, after all, is only relative, that we cannot attach much signification to it as a diagnostic sign and can only say that as the retina and the source of illumination depart from the positions of conjugate foci, the retinal illuminated area becomes, *pari passu*, blurred in outline, and, of course, if its outline is blurred, the outline of its image must be proportionately blurred.

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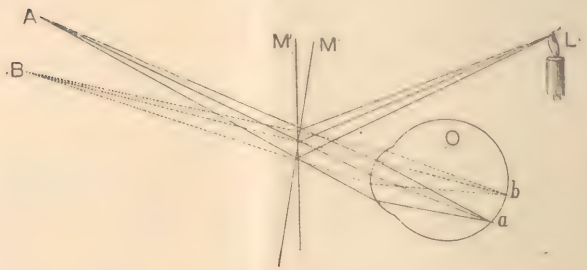
[1] Schmidt Rimplers's plan of determining refraction by the indirect method of ophthalmoscopic examination has its basis on this principle.

EXAMINATION WITH THE PLANE MIRROR.

The chief differences in the use of the concave and plane mirrors in making the "shadow-test" consist in changes in the position of the source of illumination and in the relations of the movement of the mirror and the shadow. The causes of this difference will be apparent at once on an examination of Fig. 4. The light diverging from the flame L behind the eye and falling upon the plane mirror M will be reflected and assume a direction as if it came from A, situated the same distance behind the mirror as L is in the front of it, A thus becoming the real source of illumination. These rays entering the eye O will form the illuminated area *a*. When the mirror is rotated to the position M′, in accordance with the same law, B becomes the source of illumination and forms the retinal bright area at *b*.

FIG. 4.



The relation of these movements to each other, it will be observed, are the opposite of those we found when using the concave mirror. There the source of illumination moved in the same direction with the mirror, here in the opposite direction; there the bright area on the

fundus moved in the opposite direction to the mirror, here in the same direction. This necessarily entails a difference in the relative movements of the mirror and of the image of the retinal bright area, with its shadowy edge formed by the optical apparatus of the eye, and which we observe for diagnostic purposes. This image of the retinal bright area is always found on a line passing through the centre of the bright area and the nodal point of the eye, as shown in Fig. 1, and the same law, in this particular, applies to both methods, but it is apparent at a glance that those images formed *in front* of the mirror, between the observed eye and the mirror M, move *against* the mirror, while those formed behind the mirror (weak M.), and at infinity (E), and behind the eye (H), must move *with* the mirror.

The law regarding the *rate of movement* is the same here as with the use of the concave mirror.

As regards the *brightness* of the area and the sharpness of the shadow edge, what has been said under the head of the concave mirror applies here. It is apparent, however, that since the source of illumination is always behind the mirror, we can never have even one point where the brightness is as intense and the shadow so sharply defined as we can have it in some degrees of myopia with the other method, and for the simple reason that the conjugate focus of the retina and source of illumination, are never in front of the eye of the observer.

Recapitulating, then, the shadow phenomena with a plane mirror, we have:

1. Movement of shadow *with* the mirror—E., H. or weak M.

2. Movement *against* the mirror—M with its far-point between the observed and the observing eye.

3. The slower the movement the greater the degree of ametropia (M. or H.).

As regards the relative merits of the two methods,

there exists quite a difference of opinion among those practising them. There is, however, one advantage connected with the use of the plane mirror, which has caused me to give it a preference over the concave in the usual routine examinations. Unless the concave mirror has a very long focus—longer than that of the mirrors of our ordinary ophthalmoscopes—it is necessary to keep comparatively close to the observed eye—certainly not farther away than sixty inches—in order to have sufficient illumination. If we get farther away than this, the cone of light becomes so large by the time it reaches the face that the manipulation of the mirror is rendered somewhat difficult and the illuminated area on the fundus so faint as to be almost indistinguishable, particularly if the eyes are dark. This makes it impossible accurately to detect myopia weaker than 0.75 D. With the plane mirror, however, the farther you get away from the eye under examination (within certain limits) the smaller the light area on the face becomes until the rays reflected from it become essentially parallel. This last point is reached when the distance from the mirror to the light is about one hundred inches. It is possible, with the plane mirror, to get from one hundred and twenty to one hundred and sixty inches from the observed eye, and have a fairly good illumination, and thus measure 0.25 D. of myopia if necessary.

Another reason for the more general use of the plane mirror, in this country at least, is that the concave mirrors on most of the ophthalmoscopes in use here are "tilting" segmental mirrors, ill-fitted for this method of examination. Besides, a plane mirror is very useful for other ophthalmoscopic purposes, and you should always have one on hand. I have combined the "tilting" and plane mirrors in my own ophthalmoscope [1] in a very con-

[1] Manufactured by Queen & Co., Philadelphia. For description see Trans. Amer. Oph. Soc., 1887.

venient manner, by having the tilting concave mirror swung in front of the plane one. The plane mirror does not interfere in the least with the concave mirror when the latter is in use, and when it is desired to use the plane mirror alone, the tilting mirror can be detached in a second from its upper bearing and fastened below, leaving the plane mirror free. After a constant use of this instrument for over a year, I have every reason to be satisfied with the arrangement.

Up to this point, however, we have been able to tell only the kind, but not the *degree of ametropia*, except, in a general way, by the amount of shadow movement compared with what we know it to be in emmetropia. This is by no means sufficient for accurate diagnostic purposes. The simplest as well as the best means of accomplishing this is to place in front of the eye, under examination, glasses of a kind to correct the faulty refraction that is present, one after another, until one is found that gives an emmetropic shadow movement. For example: Suppose the examination is made by means of the concave mirror and at a distance of fifty-three inches (1.33 m.), and that the movement is *with* the mirror and rather slow as compared with the mirror movements. This, we know, is myopia—and at least of medium degree. We then put in the trial frame a — 3 D. and place it in front of the eye under examination and see what shadow movements we get through this. There is still movement with the mirror, but it is more rapid than before. This shows that there is myopia yet greater than 3 D. We try —4, and still there is movement with the mirror. A — 5 gives very slight movement against the mirror. This shows that the aërial image is formed behind the observing eye. If — 4.75 or — 4.5 give movement with, we may know that the — 5 D. has reduced the M. to about 0.75 — that is, to a myopia having a far-point at fifty-three inches (1.33 m.) from

the eye, or near the observing eye. Add this to the — 5, and we have — 5.75 D. as expressive of the myopia of the eye under examination. In other words, find the weakest lens which at a distance of fifty-three inches from the eye gives a reverse movement, then add 0.75 and you have the lens required in myopia.

If it is hypermetropia, of course you must subtract 0.75, for in order to obtain a reversal of movement you have to induce a M. of 0.75 D., and a reversal produced by + 4, for instance, means a H. of 4.25 D., the other 0.75 being required to bring the far-point from infinity to the position of reversal in front of the observer. Of course, if the plane mirror is used, you can get much farther away, as far indeed as one hundred and sixty inches, where an ametropia of 0.25 D. can be measured directly—since the far-point of a myopia of 0.25 D. is at one hundred and sixty inches (4 m.), and where, necessarily, is found the point of reversal of shadow movement.

The disadvantages of the method you see at once to be the consumption of time in placing and replacing the different lenses in the trial frame in front of the eye. To obviate this, to some extent, Mr. Doyne, of Oxford, England, has devised a disk with a flange like the edge of a dinner-plate, in which is fitted a series of lenses. This disk is placed in front of the patient and while the flat surface stands obliquely to the plane of the face the flange with its lenses lies parallel to it and at right angles to the visual axis. The disk, which is about 1½ feet in diameter, standing thus obliquely, can be revolved on its axis in such a way as to bring the lenses successively in front of the eye under examination by a person with an arm of an average length at a distance of about fifty inches.[1]

[1] Since the MS. has been in the hands of the printer I have myself arranged a disk of hard rubber containing 25 lenses, each 3

Another method, first suggested, I believe, by Chibrte, but also by Jackson, of Philadelphia, is to move the mirror toward the eye under examination until the point of reversal is found; then the distance from the observed to the observing eye marks the far-point of the eye under examination. This is an excellent method for rapidly detecting, in a rough manner, the degree of myopia; and for other cases an artificial myopia can be induced by means of a convex lens of a known focus. The point of reversal through this lens being found, the strength of the lens is to be subtracted from the myopia thus manifested.

If, for example, we use a + 5 D. with a focus of 20 cm. (eight inches) $\left(\frac{100}{XX} = 5\right)$ and we find the point of reversal at 20 cm., we know there is emmetropia (5—5= 0). If the point of reversal is at 33 cm. (thirteen inches), we have $5-\left(\frac{100}{XXXIII} =\right)3 = 2$ D. of hypermetropia; if at 50 cm. (twenty inches), $5-\left(\frac{100}{L} =\right)2 = 3$ D. of H., and so on. If there is H. higher than 5 D., we must use a + 8 D. or even + 10 D. in the trial frame.

THE DETERMINATION OF ASTIGMATISM.

Probably the most valuable application of the shadow test is to the unravelling of the tangled and complicated threads of evidence which so often present themselves in

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cm. in diameter, in such a way as to enable the patient to revolve it and bring each one successively, as required, before the eye under examination. The disk can be attached to a stand or fastened by an arm to the wall of the ophthalmoscopic room. I find it to be easily manipulated, and, enabling the observer to get at a greater distance from the patient, is more convenient than the apparatus of Doyne. A graduated tape, attached to the disk, enables the observer to tell exactly his distance from the observed eye.

determining astigmatism. A few movements of the mirror are often sufficient to fix the character of an astigmatism, concerning which a tedious examination with glasses failed to give any satisfactory knowledge.

The ease with which this is done is readily understood when we remember that astigmatism is only a difference in the refraction of the opposing meridians of the eye and that we can, by changing the axis of rotation of the mirror, test successively the refraction of each separate meridian. We are further assisted, moreover, in determining astigmatism by some peculiarities of shadow-movement due entirely to the astigmatic refraction.

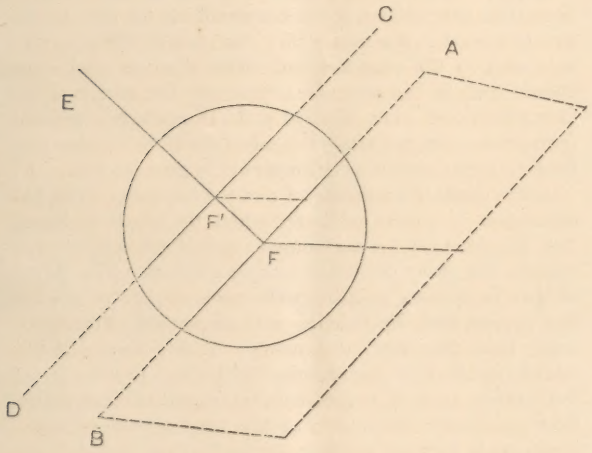
In testing for astigmatism we follow the same general plan as for general ametropia, the only difference being that we do not limit the rotation of the mirror to one direction. We rotate first horizontally then vertically, and if the shadow movements are of the same character and degree and particularly if the edge of the shadow always moves strictly in the direction of the mirror movement (with or against), we may know that no astigmatism exists. If, however, we find a difference either of kind or amount of shadow movement in the opposing meridians, or that the shadow edge moves obliquely to the mirror movement, astigmatism certainly is present.

The obliquity of shadow movement is not only valuable in giving us knowledge of the existence of astigmatism, but especially in showing us the direction of the faulty meridian. The reasons for this are as follows:

In our studies of astigmatism we found that the image of a point, or circular area of light formed by an astigmatic system, was not a point but a series of ellipses whose axes coincided with the greatest and least refracting meridians. Now, the image of the light spot on the fundus, formed by the astigmatic refracting media of the eye, is likewise an ellipse with its axes corresponding to

the meridians of least and greatest refraction. Moreover, the ellipse is so large that the small part of it that is seen by the observer passing across the pupil space appears almost straight, as, indeed, does the edges of the circular image in the non-astigmatic eye. When, however, there is an obliquity of the axis of the faulty meridian, and the mirror is rotated horizontally, we will say, the shadow does not appear to pass horizontally across the pupil, but in a direction at right angles to the axis of ellipse. You can demonstrate this experimentally by holding a body with the straight edge behind a round opening in a board, as A B Fig. 5, and moving it horizon-

FIG. 5.



tally to C D. Although the movement may have been strictly horizontal, the apparent movement, as seen through the opening, will be in the direction of E, at right angles to the edge. So you have only to make the rotations of the mirror horizontally and vertically and

the direction in which the edge of the shadow moves will indicate the direction of the faulty meridian.

To determine the amount of astigmatism, the same plan precisely is to be followed as in the determination of general ametropia—that is, we work out the refraction in each meridian separately with spherical lenses or by finding the point of reversal of movement, in the manner already indicated. In these examinations of each separate meridian we should always make the rotation of the mirror strictly at right angles to its axis and in the direction of the shadow movement, otherwise there are likely to be confusion and error, particularly when one meridian is at or near 45°.

When the kind and degree of the astigmatism have been thus determined, a cylinder suitable for the correction is placed in the frame with the axis in the direction indicated in the examination. The shadow movement should then be the same on rotation of the mirror in all directions; and when there is general ametropia present (compound astigmatism), the addition of the correcting spherical lens should give emmetropic movements.

A few general observations and we are done. The examination is somewhat easier when the pupil is large, but the necessity for a mydriatic is felt far less in this than in the direct ophthalmoscopic method. The flame should be behind and, by preference, above the head of the patient and the face as free as possible from light other than that from the mirror. It has been called a simple method of testing the refraction, and so it is; but simple as it is, it cannot be mastered without painstaking care as to the smaller details; and considerable experience is necessary before it can be executed with the rapidity and certainty of which it is capable, and which are among its recommendations to the practitioner. It will not supplant all other means of determining refraction, but it is certainly scientific, as we trust we have shown, and by care and patient practice can be made as reliable as any.

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